



General

Guideline Title

ACR Appropriateness Criteria® suspected osteomyelitis, septic arthritis, or soft tissue infection (excluding spine and diabetic foot).

Bibliographic Source(s)

Beaman FD, von Herrmann PF, Kransdorf MJ, Adler RS, Amini B, Appell M, Arnold E, Bernard SA, Greenspan BS, Lee KS, Tuite MJ, Walker EA, Ward RJ, Wessell DE, Weissman BN, Expert Panel on Musculoskeletal Imaging. ACR Appropriateness Criteria® suspected osteomyelitis, septic arthritis, or soft tissue infection (excluding spine and diabetic foot). Reston (VA): American College of Radiology (ACR); 2016. 15 p. [41 references]

Guideline Status

This is the current release of the guideline.

This guideline meets NGC's 2013 (revised) inclusion criteria.

Recommendations

Major Recommendations

ACR Appropriateness Criteria®

Clinical Condition: Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot)

Variant 1: Suspected osteomyelitis, septic arthritis, or soft tissue infection (excluding spine and diabetic foot). First study.

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9		Varies
CT area of interest with IV contrast	1		Varies
CT area of interest without IV contrast	1		Varies
CT area of interest without and with IV contrast	1		Varies
MRI area of interest without IV contrast	1		O
MRI area of interest without and with IV contrast	1		O
US area of interest	1		O

Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate	Rating	Comments	*Relative Radiation Level
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Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

Variant 2: Soft-tissue or juxta-articular swelling. Suspected soft-tissue infection. Additional imaging following radiographs.

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without and with IV contrast	9	Radiographs and MRI are both indicated and complementary. This procedure provides better delineation of fluid collection and areas of necrosis with contrast.	O
MRI area of interest without IV contrast	7	This procedure is an alternative to MRI without and with contrast if contrast is contraindicated.	O
CT area of interest with IV contrast	6	Contrast is preferred to help with soft-tissue evaluation if it can be given.	Varies
US area of interest	5	This procedure may be useful following radiographs for evaluation of juxta-articular regions.	O
CT area of interest without IV contrast	4		Varies
CT area of interest without and with IV contrast	1		Varies
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

Variant 3: Soft-tissue or juxta-articular swelling with a history of puncture wound. Suspected foreign body. Negative radiographs.

Radiologic Procedure	Rating	Comments	RRL*
US area of interest	8	This procedure is an alternative to CT and MRI. It is favored for radiolucent (wood, plastic) foreign body.	O
CT area of interest without IV contrast	7	This procedure is an alternative to MRI and US. It is recommended to assess for radio-opaque foreign body.	Varies
MRI area of interest without and with IV contrast	7	This procedure is an alternative to CT and US for assessing extent of infection. CT is favored over MRI for identification of foreign bodies.	O
CT area of interest with IV contrast	6	Contrast may obscure identification of the foreign body.	Varies
MRI area of interest without IV contrast	6		O
CT area of interest without and with IV contrast	1		Varies
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

Variant 4: Soft-tissue or juxta-articular swelling with cellulitis and a skin lesion, injury, wound, ulcer, or blister. Suspected osteomyelitis. Additional imaging following radiographs.

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without and with IV contrast	9	Radiographs and MRI are both indicated and complementary.	O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest with IV contrast		This procedure is an alternative to MRI without and with contrast if contrast is contraindicated. Contrast is preferred to aid in soft-tissue evaluation.	
CT area of interest with IV contrast	7	This procedure is an alternative if MRI is contraindicated.	Varies
Labeled leukocyte scan (In-111 or Tc-99m) and Tc-99m sulfur colloid marrow scan area of interest	6		☢☢☢☢
Tc-99m 3-phase bone scan and labeled leukocyte scan (In-111 or Tc-99m) area of interest	6	SPECT improves sensitivity.	☢☢☢☢
CT area of interest without IV contrast	5		Varies
Tc-99m 3-phase bone scan area of interest	5	SPECT improves sensitivity.	☢☢☢
FDG-PET/CT area of interest	2		☢☢☢☢
CT area of interest without and with IV contrast	1		Varies
US area of interest	1		O
Labeled leukocyte scan (In-111 or Tc-99m) area of interest	1		☢☢☢☢
Tc-99m 3-phase bone scan and labeled leukocyte scan (In-111 or Tc-99m) and Tc-99m sulfur colloid marrow scan area of interest	1		☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

Variant 5: Soft-tissue or juxta-articular swelling with a history of prior surgery. Suspected osteomyelitis or septic arthritis. Additional imaging following radiographs.

Radiologic Procedure	Rating	Comments	RRL*
Aspiration area of interest	9	This procedure is recommended if there is concern for septic arthritis.	Varies
MRI area of interest without and with IV contrast	9	This procedure is recommended for evaluation of osteomyelitis and extent of infection. It may be complementary to aspiration for evaluation of septic arthritis. Contrast is preferred if not contraindicated.	O
MRI area of interest without IV contrast	7	This procedure is recommended for evaluation of osteomyelitis and extent of infection. It may be complementary to aspiration for evaluation of septic arthritis. Contrast is preferred if not contraindicated.	O
CT area of interest with IV contrast	6	This procedure may be helpful if MRI is contraindicated or extensive MRI artifact from metal is present.	Varies
CT area of interest without IV contrast	5	This procedure may be helpful if MRI is contraindicated or extensive MRI artifact from metal is present.	Varies
Labeled leukocyte scan (In-111 or Tc-99m) and Tc-99m sulfur colloid marrow scan area of interest	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	☢☢☢☢

Radiologic Procedure	Rating	Comments	RRL*
Labeled leukocyte scan (In-111 or Tc-99m) area of interest	2		☢☢☢☢☢
Tc-99m 3-phase bone scan and labeled leukocyte scan (In-111 or Tc-99m) area of interest	2		☢☢☢☢☢
CT area of interest without and with IV contrast	1		Varies
US area of interest	1		O
Tc-99m 3-phase bone scan area of interest	1		☢☢☢☢
Tc-99m 3-phase bone scan and labeled leukocyte scan (In-111 or Tc-99m) and Tc-99m sulfur colloid marrow scan area of interest	1		☢☢☢☢☢
FDG-PET/CT area of interest	1	This is promising new technology but data are limited.	☢☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

Variant 6: Pain and swelling or cellulitis associated with site of previous nonarthroplasty hardware. Suspected osteomyelitis or septic arthritis. Additional imaging following radiographs.

Radiologic Procedure	Rating	Comments	RRL*
Aspiration area of interest	9	This procedure is recommended if there is concern for septic arthritis.	Varies
MRI area of interest without and with IV contrast	9	This procedure is recommended for evaluation of osteomyelitis and extent of infection. It may be complementary to aspiration for evaluation of septic arthritis.	O
MRI area of interest without IV contrast	8	This procedure is an alternative to MRI without and with contrast if contrast is contraindicated.	O
CT area of interest with IV contrast	7	This procedure is an alternative if MRI is contraindicated or extensive MRI artifact from metal is present.	Varies
Labeled leukocyte scan (In-111 or Tc-99m) and Tc-99m sulfur colloid marrow scan area of interest	7	This procedure is an alternative to CT and MRI if extensive hardware is present.	☢☢☢☢☢
CT area of interest without IV contrast	5		Varies
Labeled leukocyte scan (In-111 or Tc-99m) area of interest	2		☢☢☢☢☢
Tc-99m 3-phase bone scan area of interest	2		☢☢☢☢
Tc-99m 3-phase bone scan and labeled leukocyte scan (In-111 or Tc-99m) area of interest	2		☢☢☢☢☢
FDG-PET/CT area of interest	2		☢☢☢☢☢
CT area of interest without and with IV contrast	1		Varies
US area of interest	1		O
Tc-99m 3-phase bone scan and labeled leukocyte scan (In-111 or Tc-99m) and Tc-99m sulfur colloid marrow scan area of interest	1		☢☢☢☢☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

of interest	Radiologic Procedure	Rating	Comments	RRL*
	Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

Variant 7: Draining sinus (not associated with a joint prosthesis). Suspected osteomyelitis. Additional imaging following radiographs.

Radiologic Procedure	Rating	Comments	RRL*
MRI area of interest without and with IV contrast	9		O
MRI area of interest without IV contrast	7	This procedure is an alternative to MRI without and with contrast. Contrast is preferred if not contraindicated.	O
CT area of interest with IV contrast	6	This procedure may be useful if MRI is contraindicated or extensive MRI artifact from metal is present.	Varies
CT area of interest without IV contrast	6	This procedure may be useful if MRI is contraindicated or extensive MRI artifact from metal is present.	Varies
CT area of interest without and with IV contrast	3		Varies
US area of interest	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

Variant 8: Clinical examination suggesting crepitus. Suspected soft-tissue gas. First study.

Radiologic Procedure	Rating	Comments	RRL*
X-ray area of interest	9		Varies
CT area of interest with IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating. X-ray is the preferred initial study. Contrast is preferred for evaluation of possible concomitant soft-tissue abscess.	Varies
CT area of interest without IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating. X-ray is the preferred initial study. This procedure may be appropriate if there is contraindication to contrast.	Varies
CT area of interest without and with IV contrast	1		Varies
MRI area of interest without IV contrast	1		O
MRI area of interest without and with IV contrast	1		O
US area of interest	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

Variant 9: Initial radiographs showing soft-tissue gas in absence of puncture wound.

Radiologic Procedure	Rating	Comments	RRL*
CT area of interest without IV contrast	6	CT is useful due to rapid acquisition and high sensitivity.	Varies
CT area of interest with IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating. CT is useful due to rapid acquisition and high sensitivity.	Varies
MRI area of interest without IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	O
MRI area of interest without and with IV contrast	5	This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating.	O
CT area of interest without and with IV contrast	1		Varies
US area of interest	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Note: Abbreviations used in the table are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Introduction/Background

Osteomyelitis is a common problem in clinical practice. Contiguous spread from a soft-tissue infection, direct inoculation following surgery or trauma, and hematogenous seeding during bacteremia all can lead to bone infection. Early detection and diagnosis are key to preventing chronic bone destruction and resultant deformity. Although rare, squamous cell carcinoma can arise in chronic soft-tissue sinus tracts associated with osteomyelitis. Differentiating soft-tissue from osseous infection often determines the appropriate clinical therapeutic course. Imaging plays a central role in characterizing soft-tissue and osseous infections by identifying the location, evaluating the extent of involvement, and detecting complications such as soft-tissue abscesses or sinus tracts.

Hematogenous seeding (primarily affecting the metaphyses of long bones) is the primary form of osteomyelitis seen in the pediatric population. Although the average age is 10 years, >50% of cases occur in patients 5 years and younger. The majority involves the lower extremities.

Septic arthritis, or joint infection, is a rapidly progressive, debilitating process noted for significant morbidity or mortality. Patients typically present with pain localized to a single joint, erythema, soft-tissue swelling, and diminished range of motion. In children, over half of cases occur in the 2- to 3-year-old age range and below, with the majority involving lower-extremity joints.

Overview of Imaging Modalities

Because radiographs are safe, inexpensive, quickly obtained, and widely available, they should be the initial imaging test in cases of suspected musculoskeletal infection. Although often not diagnostic in acute osteomyelitis, they provide anatomic evaluation of the affected site, depict changes of chronic osteomyelitis, can reveal gas or foreign bodies, and can suggest alternative diagnoses such as neuropathic arthropathy, fracture, or tumor, which influence subsequent imaging selection and interpretation. Fluoroscopy plays a role in directing joint aspirations to differentiate inflammation and infection.

With its inherent sensitivity for bone marrow abnormalities, superb soft-tissue contrast, and delineation of anatomic detail, magnetic resonance imaging (MRI) is the modality of choice for suspected bone and extremity soft-tissue infections. It likewise is the standard for evaluating the extent of osseous and soft-tissue involvement and for following treatment response. Although MRI does offer additional advantages, including multiplanar imaging and lack of ionizing radiation, drawbacks include potential difficulty in distinguishing infection from reactive inflammation, artifact produced by orthopedic hardware, and patient contraindications such as non-MRI-compatible implanted devices or severe claustrophobia. MRI has a

100% negative predictive value for excluding osteomyelitis; a normal marrow signal reliably excludes infection. Positive cases show decreased T1-weighted bone marrow signal, with increased signal on fluid-sensitive sequences such as T2-weighted fat-saturated and short tau inversion recovery. Studies have confirmed both high sensitivity and high specificity of T1-weighted signal abnormalities for assigning true positive and true negative in suspected osteomyelitis. As with adults, MRI is the modality of choice for evaluating osseous infection in the pediatric population, particularly given radiation dose concerns.

Computed tomography (CT) depicts cortical bone well and so can play a role in the diagnosis of chronic osteomyelitis. Periosteal reaction, bone destruction, necrotic bone (sequestra), and sinus tracts are evident on CT, as are soft-tissue infections such as cellulitis and abscess. CT is particularly sensitive to soft-tissue gas (that can signal necrotizing fasciitis) and foreign bodies. CT in fact is superior to MRI for the diagnosis of sequestra, foreign bodies, and gas.

Ultrasound (US) plays a complementary role in the evaluation of osteomyelitis, primarily for detection and characterization of soft-tissue infections. US excels in detecting subperiosteal and soft-tissue abscesses, tenosynovitis, joint effusions, and radiolucent foreign bodies (e.g., wood or plastic). Both CT and US can be used in cases of percutaneous abscess drainage. In some clinical circumstances, US is favored for ease of use and lack of ionizing radiation. Similarly, US can be used for joint aspiration.

Nuclear medicine examinations have long been used in the detection of infection, but their role now largely is limited to cases where MRI is contraindicated, infection is multifocal, or when the infection is associated with orthopedic hardware or chronic bone alterations from trauma or surgery. Skeletal scintigraphy is highly sensitive but lacks specificity. Bone scans can become positive as early as 1 to 2 days after the onset of clinical symptoms. A 3- or 4-phase bone scan aids in distinguishing cellulitis from osteomyelitis. Combining bone scintigraphy with a labeled leukocyte scan enhances sensitivity. A labeled leukocyte scan in concert with technetium-99 metastable (Tc-99m sulfur) colloid marrow imaging is particularly useful in cases with altered bone marrow distribution, such as joint prosthesis.

The addition of single-photon emission CT (SPECT) or SPECT/CT improves the accuracy of radionuclide scintigraphy, facilitating the differentiation between bone and soft-tissue infection. Fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography (FDG-PET) has shown high accuracy in the detection of osteomyelitis in patients with prior surgery, trauma, and orthopedic hardware. A recent meta-analysis confirmed the superiority of FDG-PET to other radionuclide examinations, with a pooled sensitivity of 92% and specificity of 92%. In children, nuclear medicine examinations for the diagnosis of infection are less common, reflecting the wide availability of MRI (including whole-body MRI) and radiation exposure concerns.

Discussion of Imaging Modalities by Variant

Variant 1: Suspected Osteomyelitis, Septic Arthritis, or Soft-tissue Infection (Excluding Spine and Diabetic Foot). First Study

In adults, the likelihood of developing osteomyelitis without an associated wound or ulceration of the adjacent soft tissue is extremely low. Thus, in the absence of a wound, the role of imaging is to diagnose soft-tissue (or less likely joint) infection to determine its extent, identify complications, and exclude other pathologies such as vascular insufficiency, fracture, or foreign body. Initial investigation should begin with radiographs to outline anatomic detail, evaluate for radiodense foreign bodies or soft-tissue gas, and exclude alternate diagnoses such as fracture, degenerative changes, or tumor.

Although radiographs are recommended as an initial screening examination, they are insensitive in the detection of acute osteomyelitis. Subtle early radiographic findings of osteomyelitis include soft-tissue swelling and obscuration of the fat planes. Following 1 to 2 weeks, osteolysis, cortical loss, and periosteal reaction ensue.

Variant 2: Soft-tissue or Juxta-articular Swelling. Suspected Soft-Tissue Infection. Additional Imaging Following Radiographs

CT and MRI are well suited to delineate the anatomic extent of soft-tissue infections, and both offer multiplanar capability. MRI is favored for its greater sensitivity in detecting inflammation as well as associated fasciitis, myositis, and areas of necrosis. US is valuable in the detection of soft-tissue fluid collections, foreign bodies, and joint effusions. Some would assert, though, that it has a more limited role, as it can underestimate disease extent, has limited visualization of deeper structures, and is hindered by bone and gas. Sonography is more valuable in young children, with their larger cartilage-to-bone ratio and small body size. Lack of radiation, no need for sedation, and bedside imaging capability are additional advantages.

In general, nuclear medicine studies are limited by low spatial resolution and low specificity in the evaluation of soft-tissue infections and are more suited for assessing osseous infections. If septic arthritis is suspected, joint aspiration should be performed either by the radiologist or the referring service. The reference standard for the diagnosis of a septic joint is a positive culture from joint aspirate; however, a negative culture does not exclude the diagnosis, especially if the patient is already on antibiotic therapy.

Variant 3: Soft-tissue or Juxta-articular Swelling with a History of Puncture Wound. Suspected Foreign Body. Negative Radiographs

In patients with a puncture wound, any imaging evaluation should determine presence or absence of a retained foreign body. Such retained material in the soft tissue triggers a granulomatous reaction, and subsequently a soft-tissue infection can develop. Radiographs are indicated for initial imaging, especially if the composition of the material is unknown, and are well suited in the detection of radiodense foreign bodies such as metal, graphite, and stone. Glass is inconsistently visible radiographically, particularly if fragments are small or obscured by adjacent osseous structures. Optimal imaging for radiolucent (e.g., plastic or wood) material is US. Both US and CT allow for precise foreign body localization. CT is favored over MRI for identification of foreign bodies, being well suited for detection of radiodense bodies and wood. US, CT, and MRI have roles in the evaluation of concomitant soft-tissue infections as outlined in the discussion of Variants 1 and 2 above.

Variant 4: Soft-tissue or Juxta-articular Swelling with Cellulitis and a Skin Lesion, Injury, Wound, Ulcer, or Blister. Suspected Osteomyelitis. Additional Imaging Following Radiographs

MRI is the preferred imaging modality in the evaluation of acute osteomyelitis, with high sensitivity and specificity; importantly, a negative examination excludes osteomyelitis. MRI has high sensitivity, specificity, and interobserver agreement in the assessment of marrow edema and cortical erosions. Additionally, MRI is best suited for evaluation of the extent of osseous and soft-tissue involvement, including the presence of abscesses. Unless contraindicated, contrast should be administered for evaluation of soft tissues, articular and tendon involvement, and delineation of areas of necrosis. CT offers an alternative when MRI is contraindicated, with the caveat that it is inferior to MRI in evaluation of extent of bone infection and associated soft-tissue involvement. CT best depicts bone changes in chronic infection. Although debated, US generally is thought to be of limited value.

In evaluating suspected osteomyelitis, bone scintigraphy is most useful when the scan is negative; unfortunately, a positive study can be nonspecific. In positive cases of acute osteomyelitis, tracer uptake is present on all phases. In a meta-analysis, overall sensitivity was 83% and negative predictive value was .83, but specificity was only 45% for detection of osteomyelitis. Surprisingly, labeled leukocyte scanning likewise carries a low specificity and thus is not useful as a single examination. The combination of labeled leukocyte scan with Tc-99m sulfur colloid or Tc-99m 3-phase bone scan improves specificity in the evaluation of acute infection. Sulfur colloid imaging can distinguish normal marrow from infection, as there is no tracer accumulation in infection. The diagnostic role of FDG-PET for combined evaluation of acute and chronic bone and soft-tissue infection continues to evolve, with sensitivities as high as 95% and specificities from 75% to 99%. However, its capability for diagnosing chronic osteomyelitis and spinal infections offers greater promise. Currently, there is no evidence supporting a role for FDG-PET in the evaluation of septic arthritis since FDG also accumulates in inflammatory arthritis.

Variant 5: Soft-tissue or Juxta-articular Swelling with a History of Prior Surgery. Suspected Osteomyelitis or Septic Arthritis. Additional Imaging Following Radiographs

Variant 6: Pain and Swelling or Cellulitis Associated with Site of Previous Nonarthroplasty Hardware. Suspected Osteomyelitis or Septic Arthritis. Additional Imaging Following Radiographs

Radiographs reveal information about hardware and bone fractures, such as evidence of hardware loosening or fracture, degree of bone fracture healing or nonunion, and presence of heterotopic ossification. Chronic osteomyelitis occurs if residual infection is inadequately treated or refractory to therapy and can result from continuous infection or reactivation. Radiographs depict bone sclerosis and areas of destruction. Although complementary, radiography should not be the sole or primary imaging modality.

The use of US is debated. Fistulous tracts, periosteal thickening, cortical discontinuity, juxtacortical fluid, and soft-tissue abscess have been described as sonographic signs of reactivated osteomyelitis in the setting of prior trauma or surgery. Unfortunately, the study design did not assess the presence of these findings in a control group. Additionally, US is limited by metal artifact, inability to detect bone abnormalities, and nonspecificity of subperiosteal fluid collections. CT is well suited for evaluation of fracture nonunion, hardware complications, and developing or worsening osteolysis. Features of chronic osteomyelitis on CT include periosteal reaction, trabecular coarsening, bone fragmentation, cortical erosions, and fistulae, but these features are nonspecific in the setting of trauma. Cortical abnormalities should be evaluated with caution, as they could be secondary to the trauma or surgery.

Although MRI is exceptional in the detection of acute osteomyelitis, detecting acute osseous changes in the setting of chronic post-traumatic osteomyelitis is challenging in the setting of bone altered by prior trauma or surgery. MRI is sensitive in chronic osteomyelitis, depicting soft-tissue and marrow edema, as well as alterations in tissue perfusion. Marrow signal heterogeneity following trauma or surgery limits detection of superimposed infection, as reparative fibrovascular scar tissue in the bone marrow and soft tissues can persist following surgical intervention, mimicking infection. Both CT and MRI are susceptible to hardware artifact, although technological advances with the development of artifact-reducing protocols mitigate this shortcoming.

In a meta-analysis focused on chronic osteomyelitis, bone scintigraphy sensitivity was reasonable at 82%, but specificity was poor at 25%. Scintigraphic findings of infection are difficult to distinguish from postoperative or degenerative changes. In meta-analyses, sensitivity of leukocyte scanning ranged from 61% to 74% and specificity from 77% to 88%. There was, however, particularly low leukocyte scan sensitivity (21%) in

cases of chronic osteomyelitis involving the axial skeleton. Uptake at healing fracture sites complicates bone scintigraphy. Leukocytes are not incorporated into areas of bone turnover, so white cell scans remain useful in the setting of prior trauma. Prior surgery can alter marrow distribution, and the combination of labeled leukocyte scanning with Tc-99m sulfur colloid improves examination specificity in the evaluation of acute infection.

Differentiating between infection and inflammation on FDG-PET can be impossible in the acute postoperative or post-traumatic setting. FDG tracer accumulation might not normalize until 3 to 4 months after surgery or trauma. In PET, fractures are the most common cause of false-positive results. In a small study of 33 trauma patients suspected of having chronic osteomyelitis, the sensitivity of FDG-PET was 94% and specificity was 87%. Specificity increased to 100% when evaluation was limited to the axial skeleton. Eighteen of the 33 patients had metallic hardware, and all patients were imaged at least 6 months following trauma or surgery. In this study, 2 false positives were ascribed to a prosthesis foreign body reaction and a fracture nonunion, with 1 false negative in mandibular necrosis. One group of authors showed FDG-PET accuracy of 96% for detecting infection in the setting of orthopedic hardware (primarily joint prosthesis), 91% in chronic osteomyelitis, 92% in detecting osteomyelitis in the setting of soft-tissue infections, and 87% in post-traumatic/surgical patients. These results bolster the potential diagnostic utility of FDG-PET in cases of chronic osteomyelitis or when hardware is present.

If septic arthritis is suspected prompt diagnosis and treatment are essential. Depending on the virulence of the organism, cartilage destruction can ensue rapidly, with consequent osseous erosions and osteomyelitis. Synovial thickening and enhancement, joint effusion, and inflammatory change in the juxta-articular tissue are typical imaging findings, though joint effusion can be absent in up to one-third of adult patients with septic arthritis. Early joint aspiration for diagnosis is recommended. Laboratory evaluation should include routine cultures, Gram stain, and cell count with differential. Both fluoroscopy and US can be used for joint aspiration and allow confirmation of the needle placement.

Variant 7: Draining Sinus (Not Associated with a Joint Prosthesis). Suspected Osteomyelitis. Additional Imaging Following Radiographs

A draining sinus should prompt a high clinical suspicion for chronic infection. While a well-described complication of chronic osteomyelitis, sinuses also can be secondary to abscess formation from a retained foreign body. Persistent bone infection results in continuous infection of the overlying soft tissue, with consequent formation of a sinus tract to allow pus drainage through the skin. Initial imaging typically includes radiographs of the affected bone or joint. US will detect abscesses or joint fluid and can guide percutaneous aspiration. Both MRI and CT are sensitive in the diagnosis of chronic osteomyelitis, revealing cortical thickening, cortical destruction, and soft-tissue involvement. CT will show effusions and soft-tissue fluid collections, with depiction of bone erosions more striking than on radiographs. MRI is superior in delineating the extent of involved versus uninvolved bone marrow, as well as intraosseous abscess. CT better depicts sequestrum, cloaca, and osseous erosion. Both can detect concomitant squamous cell carcinoma in a chronic sinus tract.

In a meta-analysis evaluating 23 articles comprising 1269 diagnostic evaluations for chronic osteomyelitis in 687 patients, pooled sensitivity and specificity for PET were 96% and 91%, respectively. Sensitivity suffers, however, in the setting of extensive soft-tissue inflammation or infection. An additional limitation is decreased ability to detect extent of disease without the addition of CT.

Injection of contrast medium into the fistula directly reveals whether it extends to or within bone and has been shown to surround a sequestrum. This procedure is rarely called for, given the ubiquity of CT and MRI availability.

Evaluation of suspected infection with joint prosthesis is reported in separate ACR Appropriateness Criteria®.

Variant 8: Clinical Examination Suggesting Crepitus. Suspected Soft-tissue Gas. First Study

Articular crepitus—joint grating or popping—most commonly is associated with arthritis. Conversely, extremity soft-tissue crepitus could represent soft-tissue gas, so a history of recent surgical intervention, trauma (subcutaneous emphysema), or puncture wound should be sought. Radiographs are well suited for the detection of soft-tissue gas in the extremities or juxta-articular tissues but are limited in evaluation of deep fascial gas. CT is the most sensitive means of detection of soft-tissue gas and can delineate extent and compartmental location. MRI is less sensitive than CT in the detection of soft-tissue gas. Gradient-echo imaging is useful in identifying air on MR by magnifying the susceptibility artifact. There is no role for nuclear scintigraphy.

Variant 9: Initial Radiographs Showing Soft-tissue Gas in Absence of Puncture Wound

In the absence of recent surgery, trauma, or puncture wound, soft-tissue gas is a reliable indication of infection. Gas in the deep fascial planes is a hallmark of necrotizing fasciitis and can be diagnosed radiographically. Necrotizing fasciitis is rapidly progressive, can be life-threatening, and when suspected should be treated with surgical debridement. This infection can be difficult to diagnose early or when soft-tissue gas is not present; thus, cross-sectional imaging can play a vital role in early recognition. Fascial thickening, fluid collections along the deep fascial planes, and intermuscular septal edema are MRI and CT features of deep fascial inflammation. Postcontrast imaging is favored, as lack of enhancement confirms tissue necrosis, distinguishing necrotizing from non-necrotizing fasciitis. CT remains the most sensitive modality for identification of soft-tissue gas and is

preferred in some situations due to rapid acquisition.

Summary of Recommendations

- MRI with contrast is the modality of choice in the evaluation of osteomyelitis.
- Radiographs provide anatomic evaluation, demonstrate findings of chronic osteomyelitis, and can reveal gas or foreign bodies. They might suggest alternative diagnoses such as neuropathic arthropathy, fracture, or tumor, which could influence subsequent imaging selection and interpretation.
- MRI, CT, and US are all useful in the detection and evaluation of soft-tissue infections.
- US and fluoroscopy are favored for joint aspirations, and US and CT for abscess drainage.
- Joint aspiration is recommended for evaluation of septic arthritis.
- Labeled leukocyte scan and sulfur colloid marrow scan are a useful nuclear scintigraphic combination to evaluate active infection if orthopedic hardware is present.

Abbreviations

- CT, computed tomography
- FDG-PET, fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography
- In, indium
- IV, intravenous
- MRI, magnetic resonance imaging
- SPECT, single-photon emission computed tomography
- Tc-99m, technetium-99 metastable
- US, ultrasound

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢ ☢	0.1-1 mSv	0.03-0.3 mSv
☢ ☢ ☢	1-10 mSv	0.3-3 mSv
☢ ☢ ☢ ☢	10-30 mSv	3-10 mSv
☢ ☢ ☢ ☢ ☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."		

Clinical Algorithm(s)

Algorithms were not developed from criteria guidelines.

Scope

Disease/Condition(s)

Suspected osteomyelitis, septic arthritis, or soft-tissue infection (excluding spine and diabetic foot)

Guideline Category

Diagnosis

Evaluation

Clinical Specialty

Family Practice

Infectious Diseases

Internal Medicine

Nuclear Medicine

Orthopedic Surgery

Radiology

Rheumatology

Intended Users

Advanced Practice Nurses

Health Plans

Hospitals

Managed Care Organizations

Physician Assistants

Physicians

Students

Utilization Management

Guideline Objective(s)

To evaluate the appropriateness of imaging modalities for suspected osteomyelitis, septic arthritis, or soft-tissue infection (excluding spine and diabetic foot)

Target Population

Patients with suspected osteomyelitis, septic arthritis, or soft-tissue infection (excluding spine and diabetic foot)

Interventions and Practices Considered

1. X-ray, area of interest
2. Computed tomography (CT), area of interest
 - With intravenous (IV) contrast
 - Without IV contrast
 - Without and with IV contrast
3. Magnetic resonance imaging (MRI), area of interest
 - Without IV contrast
 - Without and with IV contrast
4. Ultrasound (US), area of interest

5. Labeled leukocyte scan (indium [In]-111 or technetium-99 metastable [Tc-99m]), area of interest
 - Alone
 - And Tc-99m sulfur colloid marrow scan
6. Tc-99m 3-phase bone scan, area of interest
 - Alone
 - And labeled leukocyte scan (In-111 or Tc-99m)
 - And labeled leukocyte scan (In-111 or Tc-99m) and Tc-99m sulfur colloid marrow scan
7. Fluorine-18-labeled fluorodeoxyglucose-positron emission tomography (FDG-PET)/CT, area of interest
8. Aspiration, area of interest

Major Outcomes Considered

Utility of imaging modalities in evaluating patients with suspected osteomyelitis, septic arthritis, or soft tissue infection (excluding spine and diabetic foot)

Methodology

Methods Used to Collect/Select the Evidence

Hand-searches of Published Literature (Primary Sources)

Hand-searches of Published Literature (Secondary Sources)

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence

Literature Search Summary

A literature search was conducted in March 2014 and updated in March 2016 to identify evidence for the *ACR Appropriateness Criteria® Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot)* topic. Using the search strategies described in the literature search companion (see the "Availability of Companion Documents" field), 268 articles were found. Twenty-nine articles were used in the topic. Two hundred thirty-nine articles were not used due to either poor study design, the articles were not relevant or generalizable to the topic, or the results were unclear, misinterpreted, or biased.

The author added 12 citations from bibliographies, Web sites, or books that were not found in the literature search.

See also the American College of Radiology (ACR) Appropriateness Criteria® literature search process document (see the "Availability of Companion Documents" field) for further information.

Number of Source Documents

The literature search conducted in March 2014 and updated in March 2016 identified 29 articles that were used in the topic. The author added 12 citations from bibliographies, Web sites, or books that were not found in the literature search.

Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence

Definitions of Study Quality Categories

Category 1 - The study is well-designed and accounts for common biases.

Category 2 - The study is moderately well-designed and accounts for most common biases.

Category 3 - The study has important study design limitations.

Category 4 - The study or source is not useful as primary evidence. The article may not be a clinical study, the study design is invalid, or conclusions are based on expert consensus.

The study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);

Or

The study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;

Or

The study is an expert opinion or consensus document.

Category M - Meta-analysis studies are not rated for study quality using the study element method because the method is designed to evaluate individual studies only. An "M" for the study quality will indicate that the study quality has not been evaluated for the meta-analysis study.

Methods Used to Analyze the Evidence

Review of Published Meta-Analyses

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

The topic author assesses the literature then drafts or revises the narrative summarizing the evidence found in the literature. American College of Radiology (ACR) staff drafts an evidence table based on the analysis of the selected literature. These tables rate the study quality for each article included in the narrative.

The expert panel reviews the narrative, evidence table and the supporting literature for each of the topic-variant combinations and assigns an appropriateness rating for each procedure listed in the variant table(s). Each individual panel member assigns a rating based on his/her interpretation of the available evidence.

More information about the evidence table development process can be found in the ACR Appropriateness Criteria® Evidence Table Development document (see the "Availability of Companion Documents" field).

Methods Used to Formulate the Recommendations

Expert Consensus (Delphi)

Description of Methods Used to Formulate the Recommendations

Rating Appropriateness

The American College of Radiology (ACR) Appropriateness Criteria (AC) methodology is based on the RAND Appropriateness Method. The appropriateness ratings for each of the procedures or treatments included in the AC topics are determined using a modified Delphi method. A series of surveys are conducted to elicit each panelist's expert interpretation of the evidence, based on the available data, regarding the appropriateness of an imaging or therapeutic procedure for a specific clinical scenario. The expert panel members review the evidence presented

and assess the risks or harms of doing the procedure balanced with the benefits of performing the procedure. The direct or indirect costs of a procedure are not considered as a risk or harm when determining appropriateness. When the evidence for a specific topic and variant is uncertain or incomplete, expert opinion may supplement the available evidence or may be the sole source for assessing the appropriateness.

The appropriateness is represented on an ordinal scale that uses integers from 1 to 9 grouped into three categories: 1, 2, or 3 are in the category "usually not appropriate" where the harms of doing the procedure outweigh the benefits; and 7, 8, or 9 are in the category "usually appropriate" where the benefits of doing a procedure outweigh the harms or risks. The middle category, designated "may be appropriate," is represented by 4, 5, or 6 on the scale. The middle category is when the risks and benefits are equivocal or unclear, the dispersion of the individual ratings from the group median rating is too large (i.e., disagreement), the evidence is contradictory or unclear, or there are special circumstances or subpopulations which could influence the risks or benefits that are embedded in the variant.

The ratings assigned by each panel member are presented in a table displaying the frequency distribution of the ratings without identifying which members provided any particular rating. To determine the panel's recommendation, the rating category that contains the median group rating without disagreement is selected. This may be determined after either the first or second rating round. If there is disagreement after the second rating round, the recommendation is "May be appropriate."

This modified Delphi method enables each panelist to articulate his or her individual interpretations of the evidence or expert opinion without excessive influence from fellow panelists in a simple, standardized, and economical process. For additional information on the ratings process see the [Rating Round Information](#) document.

Additional methodology documents, including a more detailed explanation of the complete topic development process and all ACR AC topics can be found on the [ACR Web site](#) (see also the "Availability of Companion Documents" field).

Rating Scheme for the Strength of the Recommendations

Not applicable

Cost Analysis

A formal cost analysis was not performed and published cost analyses were not reviewed.

Method of Guideline Validation

Internal Peer Review

Description of Method of Guideline Validation

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

Evidence Supporting the Recommendations

Type of Evidence Supporting the Recommendations

The recommendations are based on analysis of the current medical evidence literature and the application of the RAND/UCLA appropriateness method and expert panel consensus.

Summary of Evidence

Of the 41 references cited in the ACR Appropriateness Criteria® *Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot)* document, all of them are categorized as diagnostic references including 1 good quality study, and 12 quality studies that may have design limitations. There are 25 references that may not be useful as primary evidence. There are 3 references that are meta-analysis studies.

The 41 references cited in the ACR Appropriateness Criteria® *Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot)* document were published from 1993-2014. While there are references that report on studies with design limitations, 1 good quality study provides good evidence.

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits

- Early detection and diagnosis are key to preventing chronic bone destruction and resultant deformity.
- Differentiating soft-tissue from osseous infection often determines the appropriate clinical therapeutic course. Imaging plays a central role in characterizing soft-tissue and osseous infections by identifying the location, evaluating the extent of involvement, and detecting complications such as soft-tissue abscesses or sinus tracts.

Potential Harms

- Although magnetic resonance imaging (MRI) does offer advantages, including multiplanar imaging and lack of ionizing radiation, drawbacks include potential difficulty in distinguishing infection from reactive inflammation, artifact produced by orthopedic hardware, and patient contraindications such as non-MRI-compatible implanted devices or severe claustrophobia.
- Differentiating between infection and inflammation on fluorine-18-2-fluoro-2-deoxy-D-glucose positron emission tomography (FDG-PET) can be impossible in the acute postoperative or post-traumatic setting. FDG tracer accumulation might not normalize until 3 to months after surgery or trauma. In PET, fractures are the most common cause of false-positive results.
- In a meta-analysis evaluating 23 articles comprising 1269 diagnostic evaluations for chronic osteomyelitis in 687 patients, pooled sensitivity and specificity for PET were 96% and 91%, respectively. Sensitivity suffers, however, in the setting of extensive soft-tissue inflammation or infection. An additional limitation is decreased ability to detect extent of disease without the addition of CT.

See the "Summary of Literature Review" section in the "Major Recommendations" field for further information.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults. Additional information regarding radiation dose assessment for imaging examinations can be found in the American College of Radiology (ACR) Appropriateness Criteria® Radiation Dose Assessment Introduction document (see the "Availability of Companion Documents" field).

Contraindications

Contraindications

Patient contraindications to magnetic resonance imaging (MRI) include non-MRI-compatible implanted devices or severe claustrophobia.

Qualifying Statements

Qualifying Statements

- The American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for

determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

- ACR seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply individual or society endorsement of the final document.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need

Getting Better

Living with Illness

IOM Domain

Effectiveness

Identifying Information and Availability

Bibliographic Source(s)

Beaman FD, von Herrmann PF, Kransdorf MJ, Adler RS, Amini B, Appell M, Arnold E, Bernard SA, Greenspan BS, Lee KS, Tuite MJ, Walker EA, Ward RJ, Wessell DE, Weissman BN, Expert Panel on Musculoskeletal Imaging. ACR Appropriateness Criteria® suspected osteomyelitis, septic arthritis, or soft tissue infection (excluding spine and diabetic foot). Reston (VA): American College of Radiology (ACR); 2016. 15 p. [41 references]

Adaptation

Not applicable: The guideline was not adapted from another source.

Date Released

Guideline Developer(s)

American College of Radiology - Medical Specialty Society

Source(s) of Funding

American College of Radiology (ACR) provided the funding and the resources for these ACR Appropriateness Criteria®.

Guideline Committee

Committee on Appropriateness Criteria, Expert Panel on Musculoskeletal Imaging

Composition of Group That Authored the Guideline

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Financial Disclosures/Conflicts of Interest

Not stated

Guideline Status

This is the current release of the guideline.

This guideline meets NGC's 2013 (revised) inclusion criteria.

Guideline Availability

Available from the [American College of Radiology \(ACR\) Web site](#) .

Availability of Companion Documents

The following are available:

- ACR Appropriateness Criteria®. Overview. Reston (VA): American College of Radiology; 2015 Oct. 3 p. Available from the [American College of Radiology \(ACR\) Web site](#) .
- ACR Appropriateness Criteria®. Literature search process. Reston (VA): American College of Radiology; 2015 Feb. 1 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria®. Evidence table development. Reston (VA): American College of Radiology; 2015 Nov. 5 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria®. Topic development process. Reston (VA): American College of Radiology; 2015 Nov. 2 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria®. Rating round information. Reston (VA): American College of Radiology; 2015 Apr. 5 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria®. Radiation dose assessment introduction. Reston (VA): American College of Radiology; 2015 Sep. 3 p.

Available from the [ACR Web site](#) .

- ACR Appropriateness Criteria®. Manual on contrast media. Reston (VA): American College of Radiology; 2016. 128 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria®. Procedure information. Reston (VA): American College of Radiology; 2016 May. 2 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria® suspected osteomyelitis, septic arthritis, or soft tissue infection (excluding spine and diabetic foot). Evidence table. Reston (VA): American College of Radiology; 2016. 14 p. Available from the [ACR Web site](#) .
- ACR Appropriateness Criteria® suspected osteomyelitis, septic arthritis, or soft tissue infection (excluding spine and diabetic foot). Literature search. Reston (VA): American College of Radiology; 2016. 2 p. Available from the [ACR Web site](#) .

Patient Resources

None available

NGC Status

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